

CIMPA School Final Report

Title of the school : Partial Differential Equations (PDEs) and Calculus of Variations

Dates : 29 August – 09 September 2022

Location : IMSP, Dangbo, Benin Republic

I. Summary

General presentation of the event: goals achieved, issues, links you have created in the country or the region, follow-up of your action.

This school enable us to provide graduate students and young researchers with introductory courses and specialized lectures on partial differential equations (PDE), calculus of variations, and their applications. The courses concerned contemporary methods and recent tools in PDE theory and calculus of variations with applications focussed on transport theory, shape optimization, kinetic theory, geometric analysis, control theory and engineering.

This school has reinforced and/or created new links between scientists from France, Benin, Western Africa (Nigeria, Togo, Burkina-Faso, Sénégal, ...), Central Africa (Cameroon, Chad,...), East Africa (Burundi, ...), Germany, USA, Spain and England.

A number of scientific projects are already emerging from the recent contacts made or vivided during this school by scientists from Benin, Burundi, Rwanda, Burkina-Faso, Nigeria, Cameroon, etc...

The total duration of the school scientific activities is fifty four (54) hours.

Opening ceremony

The opening ceremony of the 2022 CIMPA school on Partial Differential Equations and Calculus of Variation (PDE-CV) took place in the Auditorium of IMSP from 10 am on Thursday the 1st of September 2022 under the authority of Professor Alidou SAIBOU (Deputy Vice-Chancellor of the University of Abomey-Calavi ; UAC, in charge of Research) on behalf of the Vice-Chancellor of the University of Abomey-Calavi (Professor Félicien AVLESSI) and in presence of the Deputy Vice-Chancellor of the National University of Agriculture ; UNA, in charge of Cooperation (Prof. Carolle AYISSOU AVOCEVOU), the Director of the *Institut de Mathématiques et de Sciences Physiques ; IMSP*, (Professor Carlos OGOUYANDJOU), the Representative of the *Centre International de Mathématiques Pures et Appliquées ; CIMPA*, Professor Yacine CHITOUR, Professor Wilfrid GANGBO (University of California, Los Angeles), Professor Allen TANNENBAUM and Professor Rita TANNENBAUM from Stony Brook University (USA), Professor Franca HOFFMANN of Caltech (Member of the Organizing Committee) and of the President of the Organizing Committee (Professor Guy DEGLA). The Master of Ceremony was Mr Oscar SOSSOUKPE.

It started with the Welcome Address of IMSP Director to all the guests and participants, in particular to the speakers who came from France, Germany and USA (or would be on line from Spain and England) and to the foreign/external participants (PhD students and Postdoctoral fellows) who came from Burkina-Faso, Cameroun, Congo (RDC), France, Germany, Ghana, Nigéria, Sénégal, Tchad and Togo. IMSP Director said that it is a privilege for its institute to organize despite of the world crises (COVID-19 Pandemic, War in Ukraine and Energy crisis), this 2nd CIMPA school in 2022 after the CIMPA School on Algebra, Arithmetics and Applications (12-24 June 2022) and the 6th in Benin since 1997. He acknowledged very much the various significant effort made by CIMPA, the African Centre of Excellence for Mathematical Sciences and Applications (CEA-SMIA), the Organizing Committee and the speakers, for holding the school from the the 29th August, after having postponed it from the period of 12-25 September 2021. He urged the participants to exchange/discuss with the speakers and wished a successful outcome the school. Eventually he appreciated the work carried out by the organizing committee.

On behalf of CIMPA, Professor Yacine CHITOUR firstly expressed his profound gratitude to the Organizing Committee of the school for their remarkable effort for having prepared this school for more than two years and for setting up a good scientific programme and a wonderful work environment, specially to Prof. Franca HOFFMANN and Prof. Guy DEGLA. He also thanked the University of Abomey-Calavi through the Director of IMSP (Prof. Carlos OGOUYANDJOU) who doesn't spare his time for managing the institute. Moreover he said that Benin is an important country for mathematical activities and in which CIMPA is happy to hold regular schools would like to continue to do so. He recalled as IMSP Director said that this is the 2nd CIMPA school of Benin in 2022 and the 6th so far.

Besides, he recalled briefly the history, the vision and the description of the mathematical activities of CIMPA that target Developing Countries (and especially the training of young students as CIMPA Executive Director -Professor Christophe RITZENTHALER- is used to underlying. He specified that CIMPA is currently under the umbrella of UNESCO but it is striving to be affiliated to the European Mathematical Society (EMS).

Eventually he said that it is an honor and a pleasure for him to be present at the school and he thanked all the speakers, in particular Professors Allen and Rita TANENBAUM who came from USA, and all the participants whom he urged to create contact.

Lastly, on behalf of the Vice-Chancellor of the University of Abomey-Calavi and his staff, Professor Alidou SAIDOU, welcome all the participants to the University of Abomey-Calavi (UAC) and more precisely on the campus of the *Institut de Mathématiques et de Sciences Physiques (IMSP)* for the CIMPA school of Partial Differential Equations and calculus of Variations to be held from the 29th of August to the 09th of September 2022.

He said that he was honored to chair the opening ceremony of such a school that is the framework of international meetings, sometimes scarce, between renowned mathematicians, young researchers and students to discuss the state of art of scientific research and to solve development problems.

He thanked by the way the successive CIMPA Directors and acknowledged :

- Professor Wilfrid GANGBO and Professor Aboubacar MARCOS for having organized in the past, the CIMPA-IHES-ICTP-NSF-JTF-CDE-IMU school on Nonlinear Analysis from the 28th June to the 11th July 2010 and the CIMPA on Dynamical Systems from the 1st to the 14th July 2018 at l'IMSP,

- Professor Alain TOGBE and Professor Joel TOSSA for having organized the CIMPA-ICTP-IMU school on Algebra from the 7th to the 19th July 2014 and recently from the 12th to the 24th June 2022.

He thanked as well the CIMPA Representative (Professor Yacine CHITOUR) at this school and the Director of IMSP (Professor Carlos OGOUYANDJOU) for their efforts in running this school project.

Furthermore he congratulated the organizers of this CIMPA school that was taking place as the outcome of a double project undertaken by Prof. Franca HOFFMANN (Caltech, USA), Olivier PAMEN (Mathematics Chair, AIMS-Ghana) and Guy DEGLA (IMSP, Benin) and of which first part was accepted by the African Mathematical Union (AMU) as an African Mathematical School (AMS) held at the African Institute of Mathematical Science (AIMS)-Ghana from the 16th to the 27th of August 2021, while its advanced second part was accepted by CIMPA as a school initially for the period 30/08/2021 – 10/09/2021 but eventually postponed to the period from 29-08-2022 to 09-09-2022 due to the COVID-19 pandemic.

He acknowledged all the efforts made by the renowned lecturers who had wisely accepted to come and share their knowledge with young african scientists despite of the international crises (COVID-pandemic, Ukraine war, Climate change, ...), he wished that IMSP would reinforce its existing partnerships and create new ones with the institutions involved in the organization of the school in order to facilitate exchange and mobility programmes of students and reseachers, and to promote the establishment of multidisciplinary teams that would be ultimately able to solve real world problems relevant for the sustainable development of our respective countries.

Eventually Professor Alidou SAIDOU wished fruitful outcomes from the school and a nice stay in Benin for all the participants.

He declared the school officially opened and wished long live to the scientific researches for the

development of our country.

II. Scientific content

The activities and lectures which took place are:

Lectures in presence:

- **Course 1:** Shape Optimisation

Speaker: Pierre Lissy

- **Lecture 1:** Relaxed solutions for incompressible inviscid flows: A variational and gravitational approximation to the initial value problem.

Speaker: Ivan Moyano

- **Course 2:** Applications of PDEs to problems in complex fluids

Speaker: Rita Tannenbaum

- **Course 3:** Variational problems and applications

Speaker: Wilfrid Gangbo

- **Course 4:** Optimal Mass Transport and the Robustness of Complex Networks

Speaker: Allen Tannenbaum

- **Course:** Ill-posed problems and blow-up phenomena

Speaker: Guy Degla

- **Course 5:** Partial Differential Equations on graphs and Variational models for mathematical imaging

Speaker: Franca Hoffmann & Jeremy Budd

Online lectures:

- **Course 1:** Isoperimetric Inequalities

Speaker: Valentina Franceschi:

- **Course 2:** Spectral Geometry

Speaker: Dario Prandi

- **Lecture 1:** Nonlinear aggregation-diffusion equations : (reverse) HLS inequalities and equilibration

Speaker: José A. Carillo

- **Lecture 2:** A variational approach to the construction and Malliavin smoothness of strong solutions of SDEs with irregular drifts

Speaker: Menoukeu Pamen

Activities:

- Lightening Talks and Opening Ceremony

- Lightning Talks and 3MT Competition
- Touristic Visit at Ouidah (The historical Brazilian city type of Benin that also hosts Python Temple)

III. Participants

List of all participants (III.1) including local participants, foreign participants without CIMPA support and foreign participants supported by CIMPA (III.2).

Strong participants (with their email) that we think CIMPA should follow in case CIMPA wishes to serve as recommendation center for students applying to doctoral or postdoctoral grants, or needs natural contacts in the future, are in bold characters.

III.1 List of all participants

N°	Surname	First Names	Gender	Nationality	Email address
1.	ADOGBO	Jean-Paul	M	Benin	adogbo@ceremade.dauphine.fr
2.	AKONA	Tcha	M	Togo	tchaakona@gmail.com
3.	ALEDA	Koulinté	M	Togo	koulintealeda@gmail.com
4.	AMETANA	Edoh	M	Togo	edohmefeneo@gmail.com
5.	ASSO	Oumarou	M	Benin	assomar707@gmail.com
6.	ATTIOGBE	Anoumou	M	Senegal	anoumou.attiogbe@imsp-uac.org
7.	BASSONON	Yibour Corentin	M	Burkina-Faso	corentinbassonon@gmail.com
8.	BIDOUAN	Romziath	F	Benin	romziath.bidouan@imsp-uac.org
9.	BUDD	Jeremy	M	Germany	jeremy.budd@hcm.uni-bonn.de
10.	CHITOUR	Yacine	F	France	yacine.chitour@gmail.com
11.	DANSOU	Cyrille	M	Benin	cysegbegnille@gmail.com
12.	DEGBO	Jean-Marie	F	Benin	jean-marie.degbo@imsp-uac.org
13.	DEGLA	Guy	M	Benin	gdegla@imsp-uac.org
14.	DJIBRIL-MOUSSA	Freedath	F	Benin	freedath.djibril@imsp-uac.org
15.	DJOMEGNE NJOUJOU	LIONEL LANDRY	M	Cameroon	landry.djomegne@gmail.com
16.	DOHEMETO	Fortuné	M	Benin	fortune.dohometo@imsp-uac.org
17.	ECCLESIASTE	TOMPE WEIMBAPOU	M	Cameroon	tompeweimbapouecclesiaste@yahoo.fr
18.	Fotso Tachago	Joel	M	Cameroon	fotsotachago@yahoo.fr
19.	GANGBO	Wilfrid	M	USA	wgangbo@math.ucla.edu
20.	GOUTON	Michel	M	Benin	hounhozoukou.michel@gmail.com
21.	HASSAN	Jamilu	M	Nigeria	jhashim.mth@buk.edu.ng
22.	HOFFMANN	Franca	M	Germany	franca.hoffmann@gmail.com
23.	HOUEDANOU	Wilfrid	M	Benin	khuedanou@yahoo.fr
24.	HOUNKPE	Coffi Aristide	M	Benin	coffi.hounkpe@mathematik.uni-foreburg.de
25.	KAMENI NGWANOU	Sedrick	M	Cameroon	sedrick.ngwamou@aims-cameroon.org
26.	KENGNE	Éric Arneaud	M	Cameroon	ericarnokengne2009@yahoo.fr
27.	KOUANDE	ADECHOLA EMILE KODJO	M	Togo	kouande@ceremade.dauphine.fr
28.	LÉADI	Liamidi	M	Benin	leadiare@yahoo.com
29.	LISSY	Pierre	M	France	lissy@ceremade.dauphine.fr,
30.	LY	Mamadou Pathé	F	Senegal	moha.pathe.ly@gmail.com
31.	KPAMEGAN	Bernadin	M	Benin	kpamegan_bernadin@yahoo.fr
32.	MAHAMAT HAMIT	MAHAMAT HASSAN	M	Tchad	mahamathassan2@yahoo.fr
33.	MBEMBA	Balongana	M	France	fredmbemba.b@gmail.com
34.	MOUSSA	Djibril Aliou	M	Benin	moussadjibrilaliou@gmail.com
35.	MOYANO	Ivan	M	France	Ivan.Moyano@unice.fr

N°	Surname	First Names	Gender	Nationality	Email address
36.	NGUEMFOUO	Marcial	M	Cameroon	marcial8686@yahoo.fr
37.	NSHIMIRIMANA	Pascaline	F	Burundi	nshimirimanapascaline@yahoo.fr
38.	OGOUYANDJOU	Carlos	M	Benin	cogouy@gmail.com
39.	OWOLABI	JOHNSON ADEKUNLE	M	Nigeria	johnson.owolabi@bowen.edu.ng
40.	SADIO	Guillaume Itbadio	M	Senegal	igsadio@gmail.com
41.	SAWADOGO	Noufou	M	Burkina-Faso	noufousawadogo858@yahoo.fr
42.	SOGLO	Ambroise	M	Benin	ambroiso.soglo@gmail.com
43.	SONINHEKPON	Janvier	M	Benin	janvier.soninhekpon@imsp-uac.org
44.	TANNENBAUM	Allen	M	USA	arobertan@cs.stonybrook.edu
45.	TANNENBAUM	Rina	F	USA	rina.tannenbaum@gmail.com
46.	Tchalla	Ayékotan Messan Joseph	M	Togo	tchalla.ayekotan@gmail.com
47.	TIJANI	kazeem	M	Nigeria	kazeemtijani1987@yahoo.com
48.	TODJIHOUNDE	Léonard	M	Benin	leonardt67@gmail.com
49.	TOSSA	Joel	M	Benin	joel.tossa@gmail.com
50.	WAMBA MAKENG	Huguette laire	F	Cameroon	lauramakeng@gmail.com
51.	ZINSOU	Pascal	M	Benin	pascal.zinsou@imsp-uac.org
52.	ZONGO	Yacouba	M	Burkina-Faso	yaczehn10@gmail.com

III.2 Extract of the list of foreign participants (students) supported by CIMPA

N°	Surname	First Names	Gender	Nationality	Email address
	AKONA	Tcha	M	Togo	tchaakona@gmail.com
	ALEDA	Koulinté	M	Togo	koulintealeda@gmail.com
	AMETANA	Edoh	M	Togo	edohmefeneo@gmail.com
	ATTIOGBE	Amounou	M	Senegal	anoumou.attiogbe@imsp-uac.org
	BASSONON	Yibour Corentin	M	Burkina-Faso	corentinbassonon@gmail.com
	ECCLESIASTE	TOMPE WEIMBAPOU	M	Cameroon	tompeweimbapouecclesiaste@yahoo.fr
	MBEMBA	Balongana	M	Congo	fredmbemba.b@gmail.com
	NGUEMFOUO	Marcial	M	Cameroon	marcial8686@yahoo.fr
	SADIO	Guillaume Itbadio	M	Senegal	igsadio@gmail.com
	SOAMPA	Bangan	M	Togo	bangansoampa@gmail.com
	TIJANI	Kazeem	M	Nigeria	kazeemtijani1987@yahoo.com
	ZONGO	Yacouba	M	Burkina-Faso	yaczehn10@gmail.com

IV. Financial Report

List of all grants received for the organisation of your school, with details about expenses made with CIMPA funding.

Budget CIMPA

N	Surname and First Names	Country	Statut	Number of Days	Restaurant		Number of Days	Accommodation		Kits	Total
					Unit price	Amount		Unit price	Amount		
1.	AKONA Tcha	Togo	PhD Student	14	26.5	371	14	11	154	50	575
2.	SOAMPA Bangan	Togo	PhD Student	14	26.5	371	14	11	154	50	575
3.	AMETANA Edoh	Togo	PhD Student	14	26.5	371	14	11	154	50	575
4.	ALEDA Koulinté	Togo	PhD Student	13	26.5	344.5	14	11	154	50	548.5
5.	TIJANI Kazeem	Nigeria	PhD Student	14	26.5	371	14	11	154	50	575
6.	BASSONON Yibour Corentin	Burkina-Faso	PhD Student	13	26.5	344.5	13	11	143	50	537.5
7.	ZONGO Yacouba	Burkina-Faso	PhD Student	13	26.5	344.5	13	11	143	50	537.5
8.	NGUEMFOUO Marcial	Cameroon	PhD Student	15	26.5	397.5	15	11	165	50	612.5
9.	ECCLESIASTE TOMPE WEIMBAPOU	Cameroon	PhD Student	15	26.5	397.5	15	11	165	50	612.5
10.	MBEMBA Balongana	Congo	PhD Student	18	26.5	477	18	11	198	50	725
11.	ATTIOGBE Amounou	Senegal	PhD Student	13	26.5	344.5	13	11	143	50	537.5
12.	SADIO Guillaume Itbadio	Senegal	PhD Student	13	26.5	344.5	13	11	143	50	537.5
Total						4478.5			1870	600	6948.5

Budget IMSP

	Country	Number	Total number of days	Accommodation		Restaurant		
				Unit price	Amount	Unit price	Amount	Total
Speakers	France	2	18	60	1080	35	630	1710
	Germany	2	26	0	0	35	910	910
	USA	3	33	60	1980	35	1155	3135
	Benin	1	13	0	0	20	260	260
Guest	France	1	5	0	0	35	175	175
Total 1					3060		3130	6190
Participants								
Local		15	12	0	0	18	3240	3240
Non-local (not supported by CIMPA)		12	14	15	2520	26.5	4452	6972
Total 2					2520		7692	10212
Total					5580		10822	16402

Budget Caltech

	Country	Number	Travel grants	
				Total
Students/Postdocs	Burkina-Faso (2) Burundi (1) Cameroon (1) Chad (1) Guinea (1) Nigeria (1) Senegal (1) Togo (1)	10	700	7000

Closing ceremony

The closing ceremony was chaired by the Director of IMSP in presence of Prof. Wilfrid GANGBO, Prof. Franca HOFFMANN and Prof. Guy DEGLA.

- Prof. Franca HOFFMANN and Prof. Guy DEGLA thanked all the lecturers who sacrificed their time to make this CIMPA school a successful reality, congratulated all the participants for having attended the whole intensive courses and advised them to keep in touch with the new contacts that they have established. They also wished a safe return to all the foreign participants.

- Prof. Wilfrid Gangbo congratulated Prof. Guy DEGLA and Prof. Franca HOFFMANN for having successfully organized this school. He also acknowledged the remarkable attention of the participants, urged them to pursue high quality research wherever possible and at any stage of the career and advised them to interact with senior researchers.

- Lastly the Director of IMSP thanked Prof. Wilfrid GANGBO for his contributions to the school from the beginning to the end, and Prof. Franca HOFFMANN for all what she did in terms of coordination, Caltech financial assistance and participant training.

He acknowledged that this school has broken somehow the scientific isolation of the participants and that they have learnt advanced and new tools of Partial Differential Equations and Calculus of Variations with some of their applications to shape optimization, spectral geometry, optimal transport theory, complex fluids, soft matters, blow-up phenomena, graph theory, etc.

He invited Prof. Wilfrid GANGBO to distribute kindly the Attendance Certificates to the participants, and declared the end of the school and wished a safe return to all the participants.

V. Pictures

Family picture (opening ceremony)



Vice Rector of University of Abomey-Calavi giving his speech at the opening ceremony



(From left to right: Prof W Gangbo; IMSP Director; Deputy Vice-Chancellor of UAC representing the Vice-Chancellor; ACE-MSIA Coordinator; Deputy Vice-Chancellor of UNA.

Prof Wilfrid Gangbo (giving a lecture)



Prof. Chitour Yacine



(Giving speech at opening ceremony)

Prof. Franca Hoffmann



Prof. Guy Degla



Touristic outing (Visit the python temple in Ouidah)



For the Organizing Committee

Guy DEGLA

Full Professor of Mathematics (IMSP)